JC20 Rec'd PCT/PTO 17 AUG 2001 09/913887

FORM PTO-1390 (REV. 11-94) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE **TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US)**		ATTORNEY'S DOCKET NUMBER 3594-041-999
INTERNATIONAL APPLICATION NO. PCT/IB00/00156	INTERNATIONAL FILING DATE February 15, 2000	PRIORITY DATE CLAIMED February 17, 1999
TITLE OF INVENTION FERROHYDROSTATIC SEPARATION METHOD AND APPARATUS		
APPLICANT(S) FOR DO/EO/US Jan SVOBODA		

Applicant herewith submits to the United States Designated/ Elected Office (DO/EO/US) the following items under 35 U.S.C. 371:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.

2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.

3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).

4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.

5. ☐ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☒ is transmitted herewith (required only if not transmitted by the international Bureau).
   b. ☒ has been transmitted by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US)

6. ☐ A translation of the International Application into English (35 U.S.C. 371(c)(2)).

7. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have been transmitted by the International Bureaus.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☐ have not been made and will not be made.

8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 37(c)(3)).

9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)) (unexecuted).

10. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.

12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.

13. ☐ A FIRST preliminary amendment.
    ☐ A SECOND or SUBSEQUENT preliminary amendment.

14. ☐ A substitute specification.

15. ☐ A change of power of attorney and/or address letter.

16. ☒ Other items or information:

    International Search Report mailed 2/5/00

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February 15, 2000

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17. ☒ The U.S. National Fee (35 U.S.C. 371(c)(1)) and other fees as follows:

CLAIMS

(1)FOR	(2)NUMBER FILED	(3)NUMBER EXTRA	(4)RATE	(5)CALCULATIONS
TOTAL CLAIMS	7 - 20	0	X $ 18.00	$ 0.00
INDEPENDENT CLAIMS	3 - 3	0	X $ 80.00	0.00
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ $ 270.00	$ 270.00
BASIC NATIONAL FEE (37 CFR 1.492(a)(1)-(5)): **CHECK ONE BOX ONLY**				
☐ International preliminary examination fee paid to USPTO (37 CFR 1.482) .... $ 690				
☐ No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)) .... $ 710				
☐ Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO $1000				
☐ International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2) to (4) .... $ 100				
☒ Filing with EPO or JPO search report .... $ 860				$ 860.00
Surcharge of $130.00 for furnishing the National fee or oath or declaration later than ☒ 30 mos. from the earliest claimed priority date (37 CFR 1.492(e)).				$ 130.00
TOTAL OF ABOVE CALCULATIONS				= 1,260.00
Reduction by 1/2 for filing by small entity, if applicable. Affidavit must be filed also. (Note 37 CFR 1.9, 1.27, 1.28).				- $ 0.00
SUBTOTAL				= 1,260.00
Processing fee of $130.00 for furnishing the English Translation later than 20 30 mos. from the earliest claimed priority date (37 CFR 1.492(f)).				+
0 TOTAL FEES ENCLOSED				$ 1,260.00

a. ☐ A check in the amount of $_ to cover the above fees is enclosed.

b. ☒ Please charge Deposit Account No. 16-1150 in the amount of $1,260.00 to cover the above fees. A copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 16-1150. A copy of this sheet is enclosed.

18. ☐ Other instructions
n/a

19. ☒ All correspondence for this application should be mailed to

PENNIE & EDMONDS LLP
1667 K STREET, N.W.
WASHINGTON, D.C. 20006

20. ☒ All telephone inquiries should be made to (202) 496-4720

NAME	SIGNATURE	REGISTRATION NUMBER	DATE
Gregory J. Gonsalves for Marcia H. Sundeen	Gregory J. Gonsalves	43,369 30,893	August 17, 2001

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FERROHYDROSTATIC SEPARATION METHOD AND APPARATUS

BACKGROUND TO THE INVENTION

THIS invention relates to a ferrohydrostatic separation (FHS) method and apparatus.

As defined in the specification of US patent 3,483, 969, a ferrofluid is a material comprising a permanent, stable suspension of ferromagnetic material in a suitable liquid carrier. A common ferrofluid comprises fine particles typically 10-8M or less in size) of magnetite in a liquid. In this case, the extremely fine nature of the particles maintains them indefinitely in suspension without sinking or agglomerating.

The use of a ferrofluid to separate materials of different densities, referred to in the art as ferrohydrostatic separation (FHS), is also known and is, for instance, described in the specification of US patent 3,483,969. The materials which are to be separated can be solid particulate materials or liquids which are immiscible with the carrier liquid of the ferrofluid. In essence, the separation process involves applying a magnetic field of a specific pattern to the ferrofluid with a view to controlling the apparent density of the ferrofluid within close limits. The materials which are to be separated are then deposited in the ferrofluid. with the result that those materials which have a density exceeding the controlled apparent density of the ferrofluid will sink in the ferrofluid while those which have a density less than

that of the ferrofluid will float in the ferrofluid. The sink and float fractions can then be recovered separately.

In all known prior art FHS separators using ferrofluids and employing electromagnets or permanent magnets with an iron yoke, the magnetic field of a specific pattern is generated in a horizontal direction with the ferrofluid situated between the pole tips of the magnet. This arrangement has the significant disadvantage that in order to achieve a magnetic field across a suitably large volume to enable the FHS technique to be used for large material throughputs, it is necessary to increase the gap between the pole tips of the magnet. This in turn results in a large and uneconomical increase in the volumes of copper and iron required to construct the magnet and, in general, in the overall size and mass of the separation apparatus. In addition, the arrangement does not lend itself to large scale-up to treat large tonnages of material.

To overcome these limitations of the conventional iron yoke-based design with a horizontally orientated magnetic field, the specification of South African patent ZA 97/9598 proposes an arrangement in which a magnetic field with specific pattern is generated in a vertical direction by means of a solenoid, typically with a ncn~uniform winding. The use of a solenoid has numerous advantages compared to the use of an iron yoke electromagnet or permanent magnet, these being set out in the aforementioned patent specification. For instance, with a solenoid it is possible to increase the throughput merely by increasing the relevant transverse dimension of the solenoid, the axial length of the air gap remaining constant.

Although the solenoid-based proposal described in the aforementioned patent specification provides the ability to scale up the FHS technique to treat large volumes of material, the relative complexity of the winding design and of the steel cladding, together with the necessity to generate a rather high magnetic field in order to achieve the desired field pattern, are inherent disadvantages. Since a modest magnetic field strength is generally required in the FHS technique these drawbacks can, however be countered by taking advantage of the high saturation magnetisation of steel.

Another disadvantage of the conventional iron yoke FHS systems is the fact that the gradient of the magnetic field is proportional to the magnetic field strength. In order to achieve a low apparent density of the ferrofluid, for example to separate low-density materials such as coal, low magnetic field gradient and field strength are required. However the field may then be unable to retain the ferrofluid in the separation gap, necessitating complicated mechanical means to prevent the ferrofluid from running cut of the gap.

SUMMARY OF THE INVENTION

According to the present invention the apparent density of a ferrofluid used in an FHS technique is controlled by a vertically orientated magnetic field generated by a C-dipole, open dipole (O-dipole) or split pair electromagnet or permanent magnet.

The required magnetic field pattern in the vertical direction, for example including constant magnetic field gradient, can be achieved in the case of a C-dipole electromagnet by appropriate design of the magnetising coils on upper and lower legs of the C-dipole and/or by controlling the relative polarity of electrical current flowing through these coils and/or by appropriate shaping of the C-dipole tips.

In the case of a split pair electromagnet, the required magnetic field pattern in the vertical direction, for example including a constant magnetic field gradient, can be achieved by appropriate design of the magnetising coils on upper and lower members of the split pair and/or by controlling the relative polarity of electrical current flowing through these coils and/or by appropriate shaping of the tips of the upper and lower members.

The required magnetic field pattern in the vertical direction, for example a constant magnetic field gradient, can be achieved in the case of an O-dipole electromagnet by appropriate shaping of the steel core of the magnet and/or by appropriate design of the magnetising coil.

Another aspect of the invention provides a method of separating materials of different density comprising introducing the materials into a ferrofluid, using a C-dipole, O-dipole or split pair magnet to generate a magnetic field to control the apparent density of the ferrofluid to a value between the densities of the materials, and separately recovering materials which sink and float therein.

Still further according to the invention there is provided a ferrohydrostatic separation apparatus for separating materials having different densities, the apparatus including a separation chamber for accommodating a ferrofluid into which the materials can be introduced, and a C-dipole, O-dipole or split pair magnet adjacent the chamber for generating a magnetic field to control the apparent density of the ferrofluid.

The use of a C-dipole, O-dipole or split pair magnet has several advantages when compared to the use of a conventional iron yoke electromagnet or permanent magnet, as follows:

1. As explained above, the throughput in the conventional system requires the gap between the pole tips to be increased. However with a C-dipole, O-dipole or split pair magnet system as proposed by this invention, throughput can be increased merely by increasing the length of the magnet, leaving the air gap between the pole tips constant. Because the number of ampere-turns required to generate a given magnetic field is dependent on the air gap, which remains constant in C-dipole, O-dipole and split pair configurations, it is possible to scale up a C-dipole, O-dipole or split pair magnet to any practical size while keeping the number of ampere-turns constant.

2. The magnetic field along the length of a C-dipole, O-dipole or split pair magnet is homogeneous. Thus the same magnetic field pattern and apparent ferrofluid density can be maintained along the full length of the magnet, and that full length can be used for separation purposes, resulting overall in a more compact separator.

3. Because a rather low magnetomotive force is required to magnetically saturate mild steel and the saturation magnetisation of mild steel is high, the magnetic field strength at the pole tips of a C-dipole, O-dipole or split pair magnet can be considerably greater than in the working gap of the iron yoke magnet used in conventional FHS systems. It is accordingly possible to use a more diluted ferrofluid having a lower density and magnetisation. This can lead to a reduction in ferrofluid costs, and it is envisaged that the efficiency of the separation process can improve as a result of the reduced viscosity of the more dilute ferrofluid.

DESCRIPTION OF EMBODIMENTS OF THE INVENTION

Figure 1 shows an electromagnet 10 which includes windings 12 arranged about the limbs 14 of an iron yoke 16 having pole tips 18. A working space 20 is defined between the pole tips 18. As indicated by the arrow, a horizontally orientated magnetic field is generated between the pole tips 18 which, at the same time, generate a vertically orientated magnetic field gradient.

In a conventional FHS separation system employing a magnet 10 of this type, a ferrofluid, typically a suspension of fine magnetite particles in stable suspension in a suitable liquid, is located in the working space 20 between the pole tips. The apparent density of the ferrofluid is controlled to a desired value by ensuring that the magnetic field gradient is kept at least approximately constant. The surfaces 22 of the pole tips must be carefully designed to ensure that the magnetic field gradient is as constant as possible.

Materials which are to be separated into fractions of different density respectively greater and less than the controlled apparent density of the ferrofluid are introduced into the ferrofluid, with the result that the denser particles sink while the less dense particles float.

As described above, in order to treat large throughputs of material, the gap between the pole tips must be increased, resulting in an increase in the volumes of iron and copper required to construct the magnet, in the energy required to

generate the magnetic field and in the overall size and mass of the separator. These increases limit the practical scale-up of the separator so that only modest throughputs can be treated using separators based on this conventional magnet design.

Reference is now made to Figures 2 to 6, illustrating embodiments of the present invention in which the conventional iron yoke magnet is replaced by a C-dipole, O-dipole (open-dipole) or split pair magnet with a mild steel core, and which are capable of separating materials at high throughput rates. Figures 2 and 3 illustrate a C-dipole magnet 24, Figures 4 and 5 illustrate an O-dipole magnet 26 and Figure 6 illustrates a split pair magnet according to the invention.

In each case, the magnet generates a vertically orientated magnetic field which has a natural gradient since the field strength is greatest on the surface of the pole tips 28. By judicious design of the windings 30 and 32 in Figures 2 and 3 and in Figure 6, and 34 in Figures 4 and 5, and by appropriate adjustment of the relative polarities of the electric current flowing in the coils it is possible to adjust the vertically orientated magnetic field gradient so that it is constant in a volume 36 of ferrofluid accommodated in a separation chamber 38.

The width 40 of the pole tips in each case is determined by the width of the separation chamber 38 which is in turn determined by the required residence time in the ferrofluid of the material which is to be separated. In Figures 2 and 3 and in Figure 6, the vertical distance 42 between the pole tips 28 is determined mainly by the vertical dimension of the chamber 38. In these embodiments, the overall length 44 of the magnet determines the throughput of the separator, and can be made as great as is practically feasible to give the required throughput. The dimensions 40 and 42, and hence the magnetomotive force required to generate the required magnetic field, are the same irrespective of the dimension 44 and accordingly of the throughput of the separator. In a typical example, the dimensions 40, 42 and 44 may be 400mm, 300mm and 1 metre (or more) respectively.

Feed material 46 is introduced into the chamber 38, typically by means of a vibratory feeder, along the entire length 44 of the magnet 24, 26. In the embodiment of Figures 2 and 3 the feed material can be introduced into the ferrofluid either from the outside, as indicated in Figure 3, or through openings (not illustrated) in the wall 48 of the magnet structure. In Figure 6 the chamber 38 is shown in particularly diagrammatic form but it will be understood that it could have a form similar to that shown in the other Figures.

As is conventional in the FHS technique, particles in the feed material which have a density less than the apparent density of the ferrofluid, as controlled by the magnetic field, will float in the ferrofluid and report to an elevated outlet 50. Particles which have a density exceeding the apparent density of the ferrofluid sink through the ferrofluid and are withdrawn through a lower chute 52. Both float and sink fractions are withdrawn continuously.

In Figures 2 and 3 the fractions can, for example, be removed on respective conveyor belts or other transport systems moving in the space 54 defined between the arms of the C-dipole magnet 24. In situations where this would be impossible because the feed material is introduced through openings in the wall 48, suitable transport systems could operate on the opposite side of the separation chamber 38.

It will be understood that in the O-dipole configuration of Figures 4 and 5 and the split pair configuration of Figure 6, the geometry of the magnet structure imposes less limitations on the positioning of the feed introduction and separated fraction withdrawal systems.

Mention was made above of the disadvantages faced by conventional iron yoke FHS systems when dealing with low density materials such as coal. However in the C-dipole, O-dipole and split pair arrangements proposed by the present invention, the magnetic field is able to hold magnetically diluted ferrofluid suitable for low density applications even at the low magnetic field gradients required to achieve separation.

It is also recognised that in conventional iron yoke FHS systems, the range of apparent densities which can be achieved with a given design of the magnetic circuit and pole tip profile is rather limited. In the C-dipole and split pair configurations proposed by the present invention, however, the magnetic field gradient and thus the apparent density of the ferrofluid can be varied widely by adjusting the electrical currents and the polarities thereof, flowing through the upper and lower windings 30 and 32. It is envisaged that apparent densities as a high as 25 gcm^{-1} could be achieved using a single C-dipole or split pair separator.

Although specific reference has been made to the use of a C-dipole, O-dipole or split pair electromagnet, the use of a C-dipole, O-dipole or split pair permanent magnet is within the scope of the invention. In these cases, variation of the apparent density of the ferrofluid is achieved by appropriate design of the core of the magnet and/or the shape of the pole tips.

CLAIMS

1.

A ferrohydrostatic separation method in which a ferrofluid is used to separate materials of different density, the method comprising the step of controlling the apparent density of the ferrofluid by means of a vertically orientated magnetic field generated by a C-dipole, open dipole (O-dipole) or split pair electromagnet or permanent magnet.

2.

A method according to claim 1 wherein a required magnetic field pattern in the vertical direction is achieved, in the case of a C-dipole electromagnet, by appropriate design of the magnetising coils on upper and lower legs of the Cdipole and/or by controlling the relative polarity of electrical current flowing through these coils and/or by appropriate shaping of the C-dipole tips.

3

A method according to claim 1 wherein a required magnetic field pattern in the vertical direction is achieved, in the case of a split pair electromagnet, by appropriate design of the magnetising coils on upper and lower members of the split pair and/or by controlling the relative polarity of electrical current flowing through these coils and/or by appropriate shaping of the tips of the upper and lower members.

4.

A method according to claim 1 wherein a required magnetic field pattern in the vertical direction is achieved, in the case of an O-dipole electromagnet, by appropriate shaping of the steel core of the magnet and/or by appropriate design of the magnetising coil.

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A method according to any one of claims 2 to 4 wherein the required magnetic field pattern includes the provision of a constant magnetic field gradient.

6.

A method of separating materials of different density comprising introducing the materials into a ferrofluid, using a C-dipole, O-dipole or split pair magnet to generate a magnetic field to control the apparent density of the ferrofluid to a value between the densities of the materials, and separately recovering materials which sink and float in the ferrofluid.

7.

A ferrohydrostatic separation apparatus for separating materials having different densities, the apparatus including a separation chamber for accommodating a ferrofluid into which the materials can be introduced, and a C-dipole, O-dipole or split pair magnet adjacent the chamber for generating a magnetic field to control the apparent density of the ferrofluid.

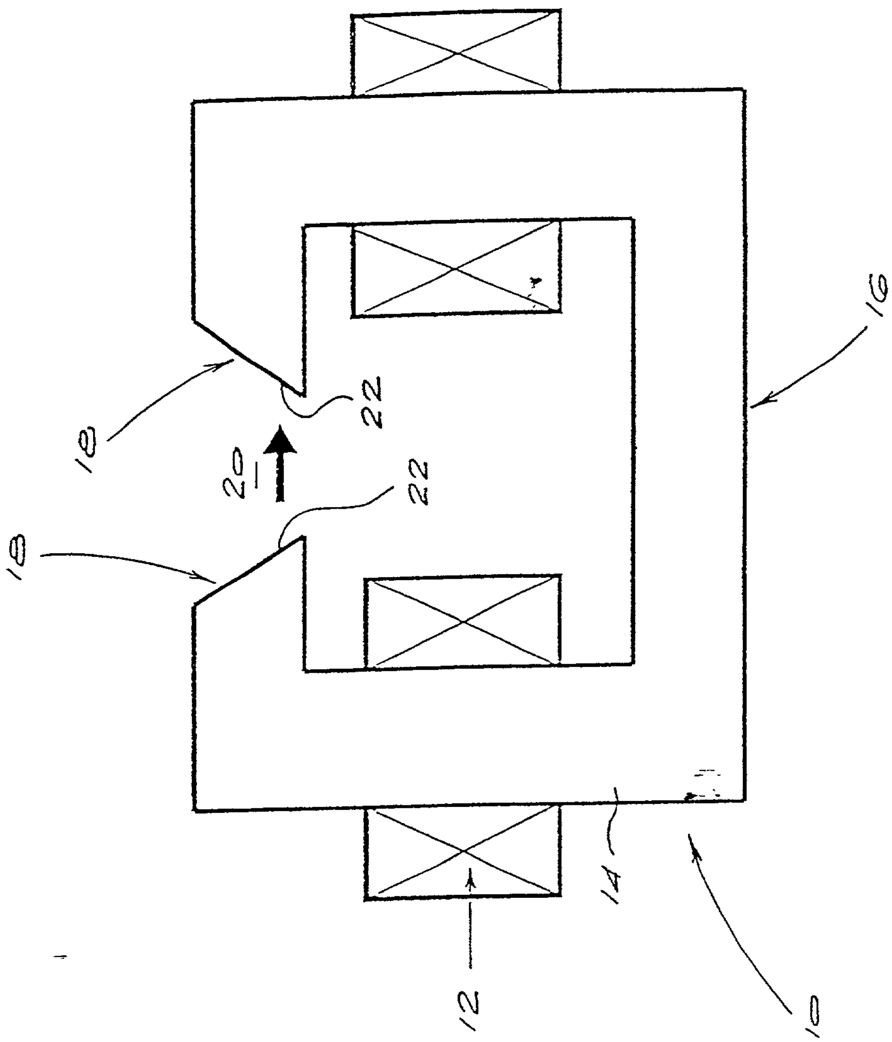
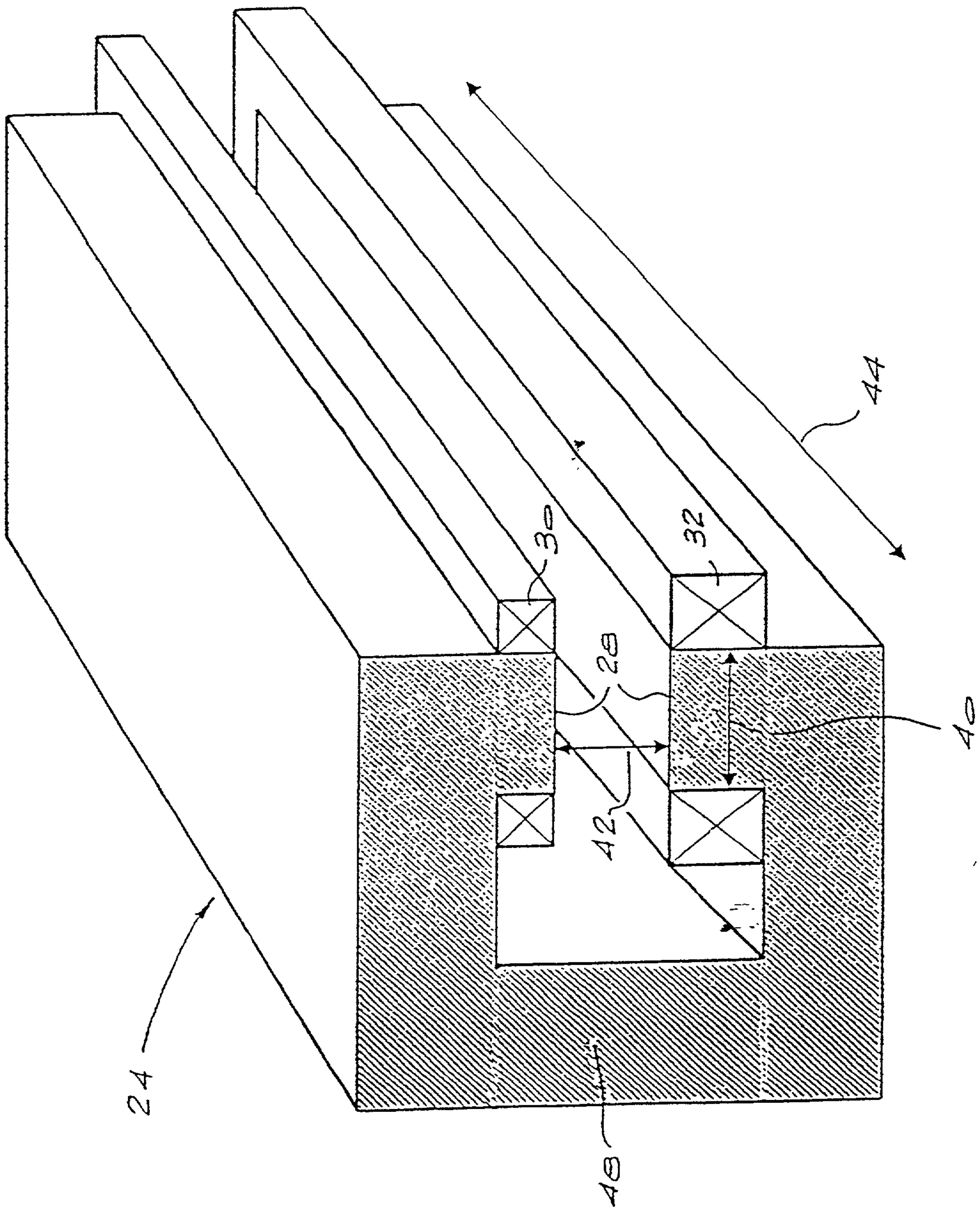


Fig 1



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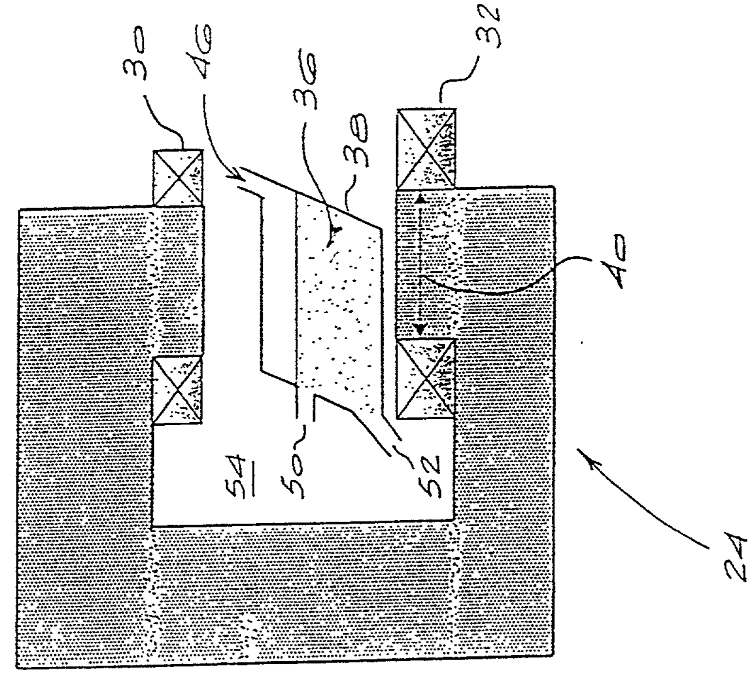

Fig 3

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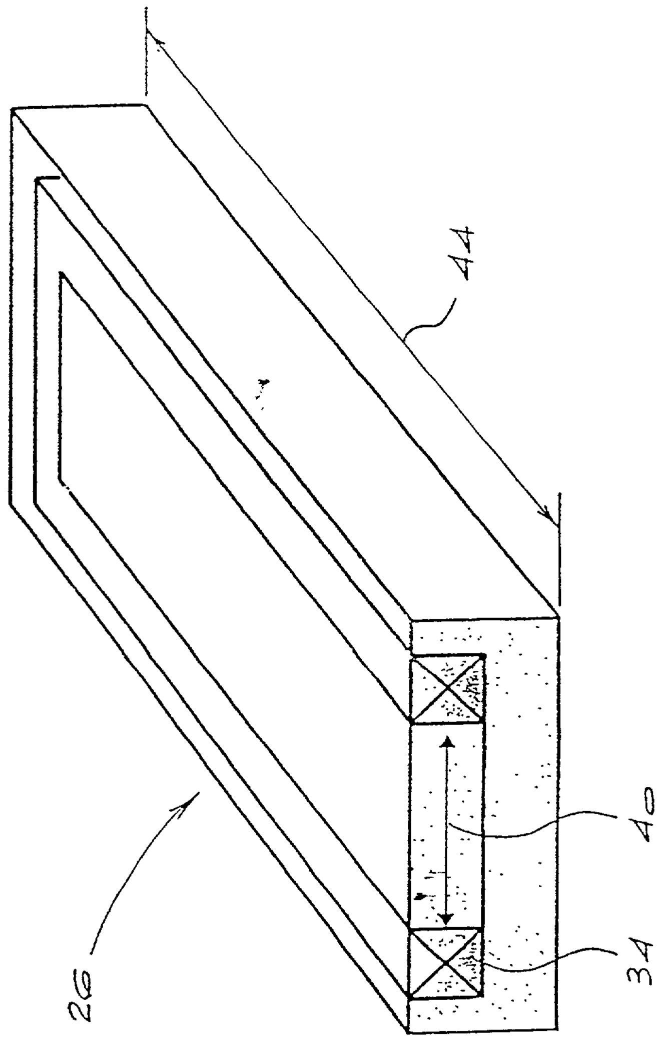

Fig 4

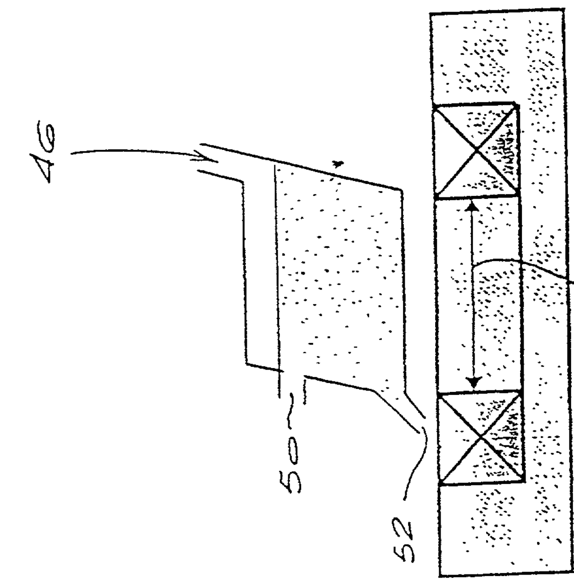

FIG. 5

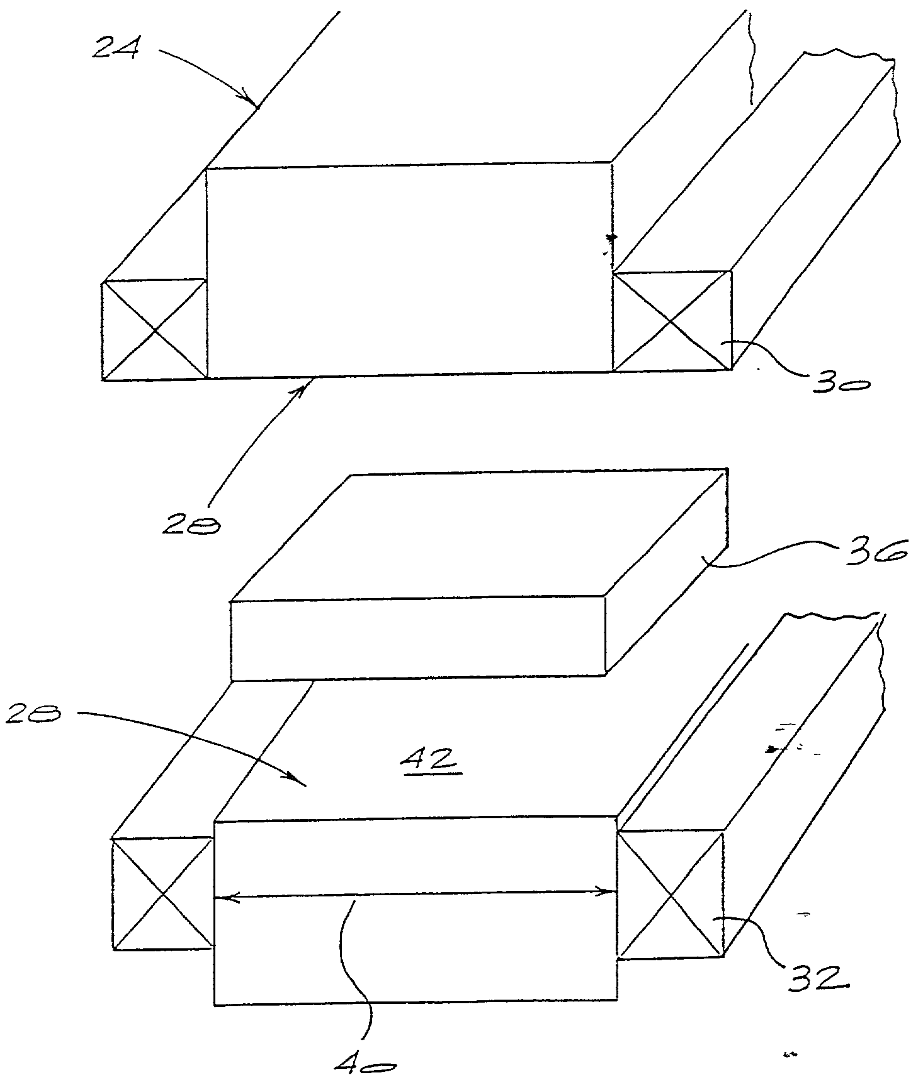

FIG 6

DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below at 201 et seq. underneath my name

I believe I am the original, first and sole inventor if only one name is listed at 201 below, or an original, first and joint inventor if plural names are listed at 201 et seq. below, of the subject matter which is claimed and for which a patent is sought on the invention entitled

FERROHYDROSTATIC SEPARATION METHOD AND APPARATUS

and for which a patent application:
☐ is attached hereto and includes amendment(s) filed on ____________ (if applicable)
☒ was filed in the United States on August 17, 2001 as Application No. 09/913, 887 (for declaration not accompanying application)
with amendment(s) filed on ____________ (if applicable)
☒ was filed as PCT international Application No. PCT/IB00/00156 on February 15, 2000 and was amended under PCT Article 19 on ____________ (if applicable)

I hereby state that I have reviewed and understand the contents of the above identified application, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, §1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, §119(a)-(d) of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

EARLIEST FOREIGN APPLICATION(S), IF ANY, FILED PRIOR TO THE FILING DATE OF THE APPLICATION				
APPLICATION NUMBER	COUNTRY	DATE OF FILING (day, month, year)	PRIORITY CLAIMED	
99/1255	SOUTH AFRICA	17 FEBRUARY 1999	YES ☒	NO ☐
PCT/IB00/00156	WIPO	15 FEBRUARY 2000	YES ☒	NO ☐

I hereby claim the benefit under Title 35, United States Code, §119(e) of any United States provisional application(s) listed below.

APPLICATION NUMBER	FILING DATE

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code §112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, §1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application:

APPLICATION SERIAL NO.	FILING DATE	STATUS		
		PATENTED	PENDING	ABANDONED

POWER OF ATTORNEY: As a named inventor, I hereby appoint S. Leslie Misrock (Reg. No. 18872), Harry C. Jones, III (Reg. No. 20280), Berj A. Terzian (Reg. No. 20060), Gerald J. Flintoft (Reg. No. 20823), David Weild, III (Reg. No. 21094), Jonathan A. Marshall (Reg. No. 24614), Barry D. Rein (Reg. No. 22411), Stanton T. Lawrence, III (Reg. No. 25736), Isaac Jarkovsky (Reg. No. 22713), Charles E. McKenney (Reg. No. 22795), Philip T. Shannon (Reg. No. 24278), Francis E. Morris (Reg. No. 24615), Charles E. Miller (Reg. No. 24576), Gidon D. Stern (Reg. No. 27469), John J. Lauter, Jr. (Reg. No. 27814), Brian M. Poissant (Reg. No. 28462), Brian D. Coggio (Reg. No. 27624), Rory J. Radding (Reg. No. 28749), Stephen J. Harbulak (Reg. No. 29166), Donald J. Goodell (Reg. No. 19766), James N. Palik (Reg. No. 25510), Thomas E. Friebel (Reg. No. 29258), Laura A. Coruzzi (Reg. No. 30742), Jennifer Gordon (Reg. No. 30753), Jon R. Stark (Reg. No. 30111),
41
Allan A. Fanucci (Reg. No. 30256), Geraldine F. Baldwin (Reg. No. 31232), Victor N. Balancia (Reg. No. 31231), Samuel B. Abrams (Reg. No. 30605), Steven I. Wallach (Reg. No. 35402), Marcia H. Sundeen (Reg. No. 30893), Paul J. Zegger (Reg. No. 33821), Edmond R. Bannon (Reg. No. 32110), Bruce J. Barker (Reg. No. 33291), Adriane M. Antler (Reg. No. 32605), Thomas G. Rowan (Reg. No. 34419), James G. Markey (Reg. No. 31636), Thomas D. Kohler (Reg. No. 32797), Scott D. Stimpson (Reg. No. 33607), Ann L. Gisolfi (Reg. No. 31956), and Mark A. Farley (Reg. No. 33170), all of Pennie & Edmonds LLP, whose addresses are 1155 Avenue of the Americas, New York, New York 10036, 1667 K Street N.W., Washington, DC 20006 and 3300 Hillview Avenue, Palo Alto, CA 94304, and each of them, my attorneys, to prosecute this application, and to transact all business in the Patent and Trademark Office connected therewith.

SEND CORRESPONDENCE TO: PENNIE & EDMONDS LLP 1667 K STREET, N.W. WASHINGTON, D.C. 20006		DIRECT TELEPHONE CALLS TO: PENNIE & EDMONDS LLP DOCKETING (202) 496-4400		

1-00

201	FULL NAME OF INVENTOR	LAST NAME SVOBODA	FIRST NAME JAN	MIDDLE NAME	
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	POST OFFICE ADDRESS	STREET 158 CORNELIS STREET	CITY FAIRLAND	STATE OR COUNTRY SOUTH AFRICA	ZIP CODE 2195
202	FULL NAME OF INVENTOR	LAST NAME	FIRST NAME	MIDDLE NAME	
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	POST OFFICE ADDRESS	STREET	CITY	STATE OR COUNTRY	ZIP CODE
203	FULL NAME OF INVENTOR	LAST NAME	FIRST NAME	MIDDLE NAME	
	RESIDENCE & CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP	
	POST OFFICE ADDRESS	STREET	CITY	STATE OR COUNTRY	ZIP CODE
204	FULL NAME OF INVENTOR	LAST NAME	FIRST NAME	MIDDLE NAME	
	RESIDENCE & CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP	
	POST OFFICE ADDRESS	STREET	CITY	STATE OR COUNTRY	ZIP CODE
205	FULL NAME OF INVENTOR	LAST NAME	FIRST NAME	MIDDLE NAME	
	RESIDENCE & CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP	
	POST OFFICE ADDRESS	STREET	CITY	STATE OR COUNTRY	ZIP CODE
206	FULL NAME OF INVENTOR	LAST NAME	FIRST NAME	MIDDLE NAME	
	RESIDENCE & CITIZENSHIP	CITY	STATE OR FOREIGN COUNTRY	COUNTRY OF CITIZENSHIP	
	POST OFFICE ADDRESS	STREET	CITY	STATE OR COUNTRY	ZIP CODE

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

SIGNATURE OF INVENTOR 201 X	SIGNATURE OF INVENTOR 202	SIGNATURE OF INVENTOR 203
DATE 11/12/01	DATE	DATE
SIGNATURE OF INVENTOR 204	SIGNATURE OF INVENTOR 205	SIGNATURE OF INVENTOR 206
DATE	DATE	DATE